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Combined Surgery for Cardiac and Carotid Disease: Management and Results of a Rational Approach

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Objectives: *the aim of the present study was to apply a rational plan for simultaneous cardiac and carotid surgery in high-risk patients.*
Materials and methods: *a consecutive series of 89 patients with coexisting severe cardiac and carotid disease were operated on during a 5-year period with routinary carotid shunting, moderate hypothermia and balanced anaesthesia. The combined surgical procedures were coronary artery by-pass grafts (CABG) + carotid endarterectomy (CEA) in 81 patients, CABG + CEA + aortic valve replacement (AVR) in four patients, and four cases of CEA + AVR.*
Results: *two deaths (2%), three acute myocardial infarctions (3%) and one (1%) major stroke occurred in five patients during the perioperative (30 days) period for a combined rate of death and/or disabling stroke of 3%. There were five reversible neurological deficits. Carotid and aortic mean clamping times were 9 and 60 min respectively. Patients were discharged after a mean length of stay in Intensive Care Unit (ICU) of 131 h and 7 days of hospitalisation post-ICU.*
Conclusions: *based on our results, combined interventions of CEA and CABG can be performed with an acceptable morbidity and mortality when severe carotid stenosis is associated with advanced, symptomatic cardiac disease. The management of these patients needs careful and appropriate pre-intra and post-operative assessment and timing aimed to reduce the ischaemic injuries, both cardiac and cerebral, especially during CBP time.*

Key Words: Endarterectomy; Coronary bypass; Cardiopulmonary bypass; Stroke.

Introduction

The management of patients with severe coronary artery disease and carotid occlusive disease is controversial.[1–5] Surgical treatment for the two territories can be combined or staged.[6–16] The best approach depends upon the cardiac and neurological condition of the patient, as well as the personal experience of the surgical teams.[17–34]

The present paper reports on results with combined carotid and coronary operations.

Materials and Methods

Simultaneous CEA and cardiac surgery is considered for all the patients with concomitant symptomatic severe cardiac disease and haemodynamically significant (≥70%) carotid artery disease (symptomatic or asymptomatic). The present study consists of a consecutive series of 89 patients (72 male, 17 female). Age ranged from 49 to 84 years (mean 67 years).

Patients having emergent surgical procedures or current active cardiac symptoms (e.g. angina with haemodynamic unstability or congestive heart failure) were excluded from the study to obtain a homogeneous group of cases (Table 1).

Preoperative angiography showed triple-vessel coronary artery disease in 70 patients, severe (>75%) left main coronary artery stenosis in six patients, and two vessel coronary artery disease in 13 patients. In 17 patients the left ventricular EF was lower than 40%.

When a carotid stenosis of 70% or more or an ulcerated carotid plaque was found on duplex, further evaluation with angiogram and cerebral computed tomography (CT) scan was required.

Operative details are shown in Table 2.

Based on the specific risk,[26] all the patients had high neurological risk scores. Of the 85 patients undergoing

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Table 1. Preoperative cardiac/neurological evaluation in 89 patients undergoing combined surgery.

	n	(%)
Cardiac history		
Myocardial infarction	56	(63)
Unstable angina (III-IV CCS)	73	(82)
Chronic stable angina (II-III CCS)	15	(17)
Aortic valve disease	11	(12)
Neurological history		
Asymptomatic	68	(77)
Stroke	6	(7)
TIA	15	(17)
Cerebral CT scan (no. 79)		
Positive	22	(28)
Negative	57	(72)
Carotid stenosis on angiogram		
≥70% and ≥50% contralateral stenoses	31	(35)
≥70% stenosis and contralateral occlusion	5	(6)
≥85% stenosis	48	(54)
≥70% stenosis and ulcerated plaque	5	(6)

CCS = Canadian classification study;[41] TIA = transient ischaemic attack.

Table 2. Operative details in 89 combined cardiac and carotid procedures.

	n	(%)
Type of surgery		
CEA + CABG	81	(91)
CEA + CABG + AVR	4	(4)
CEA + AVR	4	(4)
Number of CABG		
One bypass	9	(11)
Two bypass	17	(20)
Three or more bypass	59	(69)
Homologous blood transfusion*	56	(63)
Inotropes drug (dopamine)	32	(34)

* Mean of 2 units for patient.
CEA = carotid endarterectomy; CABG = coronary artery bypass grafting; AVR = aortic valve replacement.

CABG, 84 appeared as both high neurological and high cardiac risk while the remaining patient had high neurological risk and low cardiac risk (two vessel disease with stable angina). The four patients who underwent AVR in association with CEA were all considered as having high cardiac risk because of left ventricular EF<40%.

Preoperative baseline risk factors are shown in Table 3. In order to optimise perioperative outcome of high-risk patients scheduled for combined cardiac and CEA, we planned a defined strategy including anaesthetic and surgical management and timing of operations.

Surgical technique

In all cases CEA was performed by a separate vascular surgical team under general anaesthesia, without cerebral monitoring.

Table 3. Baseline risk-factors in 89 patients undergoing combined surgery.

	n	(%)
Diabetes	43	(48)
Chronic obstructive pulmonary disease	59	(66)
Hypertension	81	(91)
Hyperlipidaemia	33	(37)
Renal insufficiency*	12	(13)
Peripheral occlusive disease	28	(31)

* Defined *ad serum* creatinine values >1.5 mg/dl.

Table 4. Intra/postoperative times in 86 combined cardiac and carotid procedures.†

Times of procedures	Mean time (range)
Surgery	341 min (158–710)
CPB	87 min (28–216)
CEA	128 min (90–150)
Carotid clamping	9 min (2–7)
Aortic clamping	61 min (13–107)
Intubation	29 h (12–168)
Stay in ICU	131 h (19–480)
Post-ICU hospitalisation	7 days (5–25)

* Mean of 2 units for patient.
† One patient who died for multiorgan failure after prolonged interrupted in ICU intubation (1652 h) and the two patients who died in the operative period were excluded for this analysis.
ICU = Intensive Care Unit.

The patients received 5000 units of intravenous heparin and Pruitt–Inahara shunt was used in all cases. Seventy-eight were closed primarily, eight had a saphenous vein patch and three underwent eversion and reimplantation. The neck wound was left open until the reversal of heparinisation with protamine at the end of the cardiac procedure. All neck wounds were drained.

Cardiopulmonary bypass (CPB) was carried out in systemic heparinisation (heparin-sodium 300 UI/kg) with hollow fibre oxygenators (Capiox E, Terumo Corporation, Tokyo, Japan), moderate hypothermia (temperature of 30 °C) and non-pulsatil perfusion flow of 2.4 l/min/m^2 adjusted to gain a systemic blood pressure not lower than 70 mmHg. Anterograde isothermic blood cardioplegia (2 mEq/l KCl solution) was used in all the patients. During CPB haematocrit value as low as 24% was permitted, before blood transfusion.

Continuous variables were presented as mean and corresponding ranges of variability. The life table method was used for survival analysis.

Results

Perioperative (at 30 days) and postoperative data of the 89 combined procedures are displayed in Table 4.

Table 5. Perioperative (30 days) complications after 89 combined cardiac and carotid procedures.

	n	(%)
Death	2	(2)
Myocardial infarction	3	(3)
Stroke	1	(1)
Minor stroke	3	(3)
TIA	2	(2)
Transient myocardial ischaemia	10	(11)
Transient rise of creatinine >1.5 mg	19	(21)
Acute renal failure requiring dialysis	1	(1)
Surgical reopened for bleeding (from median sternotomy)	5	(6)

TIA = transient ischaemic attack.

Table 6. Lifetable follow-up.

Interval	Beg. total	Deaths	Lost	Survival	Std error	(95% CI)
0–1	89	2	0	0.98	0.02	0.91–0.99
1–12	87	4	0	0.93	0.03	0.86–0.97
12–24	83	0	40	0.93	0.03	0.86–0.97
24–36	43	0	22	0.93	0.03	0.86–0.97
36–48	21	0	7	0.93	0.03	0.86–0.97
48–60	14	1	8	0.84	0.09	0.55–0.95
60–67	5	0	5	0.84	0.09	0.55–0.95

The average time required for combined interventions was 341 min (Table 4). The time of carotid artery clamping, including both the time of positioning and the time of removal of the shunt, was about 9 min. Two (2%) patients died in the immediate perioperative period: one patient with three vessels disease and low preoperative EF died in ICU for a cardiogenic shock following extensive MI. The second patient died intraoperatively for a traumatic myocardial rupture. One patient (1.1%), formerly asymptomatic, had a severe stroke with permanent neurological deficit. The perioperative rate of death and disabling stroke was 3%; the rate of death and any stroke was of 7%. All perioperative complications regarded patients with both high neurological and high cardiac risk.

During CBP time

During ICU stay, 18 patients needed inotropic support with dopamine and five patients had homologous blood transfusions. Five patients (6%) required surgical reopening of the median sternotomy for bleeding. Perioperative morbidity and mortality are shown in Table 5.

In the postoperative period, one patient with severe preoperative chronic obstructive pulmonary disease (COPD) developed multiorgan failure and died after 3 months of interrupted postoperative intubation in ICU (1652 h). This patient was never discharged home. For the remaining post-surgery 86 survivors, the intubation times and the lengths of stay in ICU are displayed in Table 5. In the patient who experienced perioperative severe stroke, the intubation time was 144 h and the length of stay in ICU was 264 h. In all the other patients the average intubation time and the average stay in ICU time were 25 h and 74 h, respectively. Follow up was completed for all the patients. The mean follow up was 35 months (range 12–66).

Four late deaths occurred (Table 6).

Discussion

Following simultaneous CABG-CEA mortality rates vary from 2% to 12% and stroke rates vary from 1% to 15%.[27–34]

The wide variability in outcome is attributable to significant variations in patients' selection for simultaneous procedure.

Our study considered a high-risk cardiac population at high risk of perioperative stroke ($\geq$70% carotid stenosis). Despite this, there was only one major stroke and five minor neurological deficits (with complete recovery).[18,26]

We believe therefore that an aggressive non-invasive carotid screening policy may be justified for all patients scheduled for cardiac surgery. The finding of $\geq$70% carotid disease must be further evaluated with a view to a combined surgical approach.

Due to multiple potential sources for perioperative stroke during cardiac surgery, an experienced group of cardiac and vascular surgeons is required to achieve optimum results from combined cardiac and carotid surgery.[32] There are two critical phases during operation: the carotid time and the CPB time.

We suggest that CPB should be carried out in mild hypothermia since it is a very effective method for neuroprotection. It has been shown that even lowering body temperature by 2–3 °C can reduce possible ischaemic cerebral injury.[36] In our experience, all the patients but one were operated on under body temperature not lower than 30 °C: only one major stroke and five minor neurological deficits were perioperatively recorded.

Pump flows during CPB must be adjusted in order to maintain perfusion pressure not lower than 70 mm/Hg to avoid severe cerebral hypoperfusion in patients with carotid stenosis. Non-pulsatile flow is advocated

as haemodynamically advantageous for perfusion. The use of hollow fibres, oxygenators and filters along the circuit minimises the risk of emboli of inert or organic materials.

Regarding fluid support, we prefer an isovolaemic haemodilution through autologous blood collecting just before the start of CPB. The reduced blood viscosity improves the microcirculation and eventually the perfusion of ischaemic areas. Furthermore, isovolaemic haemodilution minimises blood loss. We generally avoid dextrose or lactate solutions because it has been shown that even a moderate hyperglycaemia can aggravate an ischaemic cerebral damage by raising the level of lactic acidosis. For this reason, cristalloids and colloids are preferred in our management.

Because both CBP and clamping time are well known risk factors for perioperative stroke during cardiac surgery,[30,31] the duration of each procedure in combined carotid and cardiac surgery is determinant. In a large review of 2211 patients who underwent cardiac surgery, Libman *et al.* found that bypass pump time of more than 120 min was the only significant predictor of perioperative stroke (Odds Ratio of 1:4).[31] In our 89 patients the mean duration time of combined surgeries was about 6 h (341 min), with reasonably short times of carotid clamping and CBP (mean 9 min and mean 87 min, respectively).

During the carotid surgery "light" anaesthesia with isofluorane maintains blood pressure stability avoiding hypotensive crisis and consequent use of vasopressor drugs, potentially dangerous for the heart.

During the cardiac surgery, use of balanced anaesthesia with halogenates (isoflurane), low dose of opioids (fentanyl) and hypnotics (propofol and midazolam) may help in weaning from the ventilator and permits short intubation time (mean 29 h in our experience).

We prefer the routine use of a Pruitt–Inahara shunt in all patients undergoing combined surgery. For this reason, we do not perform neurological monitoring.

In conclusion, we advise combined intervention of CEA and CABG when severe carotid stenosis is associated with advanced and symptomatic coronary disease.

A well-defined protocol used by an experienced team may help to optimise the outcomes of this challenging surgery.

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References

1 Newman DC, Hicks RG, Horton DA. Coexistent carotid and coronary arterial disease: outcome in 50 cases and method of management. *J Cardiovasc Surg* 1987; **28**: 599–606.
2 Hallpin DP, Riggins S, Carmichael JD *et al.* Management of coexistent carotid and coronary artery disease. *South Med J* 1994; **87**: 187–189.
3 Pillai L, Gutierrez IZ, Curl GR *et al.* Evaluation and treatment of carotid stenosis in open-heart surgery patients. *J Surg Res* 1994; **57**: 312–315.
4 Davenport RJ, Starkey IR, Ruckley CV *et al.* How should a patient presenting with unstable angina and recent stroke be managed? *BMJ* 1995; **310**: 1449–1452.
5 Ricotta JJ. The approach to patients with carotid bifurcation disease in need of coronary artery bypass grafting. *Semin Vasc Surg* 1995; **8**: 62–69.
6 Lusiani L, Visona A, Castellani V *et al.* Prospective evaluation of combined carotid and coronary surgery. *Eur J Cardiothoracic Surg* 1987; **1**: 16–19.
7 Jausseran JM, Bergeron P, Reggi M *et al.* Single staged carotid and coronary arteries surgery. *J Cardiovasc Surg* 1989; **30**: 407–413.
8 Hertzer NR, Loop FD, Beven EG *et al.* Surgical staging for simultaneous coronary and carotid disease: a study including prospective randomization. *J Vasc Surg* 1989; **9**: 455–463.
9 Bernstein EF. Staged versus simultaneous carotid endarterectomy in patients undergoing cardiac surgery. *J Vasc Surg* 1992; **15**: 870–871.
10 Pome G, Passini L, Colucci V *et al.* Combined surgical approach to coexistent carotid and coronary artery disease. *J Cardiovasc Surg* 1991; **32**: 757–763.
11 Carrel T, Stillhard G, Turina M. Combined carotid and coronary artery surgery: early and late results. *Cardiology* 1992; **80**: 118–125.
12 Rizzo RJ, Whittemore AD, Couper GS *et al.* Combined carotid and coronary revascularization: the preferred approach to the severe vasculopathy. *Ann Thorac Surg* 1992; **54**: 1099–1109.
13 Vermeulen FE, Hamerlijnck RP, Defauw JJ *et al.* Synchronous operation for ischemic cardiac and cerebrovascular disease: early results and long-term follow-up. *Ann Thorac Surg* 1992; **53**: 381–390.
14 Klima U, Wimmer-Grenecker G, Harringer W *et al.* Surgical management of coronary heart disease and simultaneous carotid artery stenosis. *Wien Klin Wochenschr* 1993; **105**: 76–78.
15 Chang BB, Darling RC III, Shah DM *et al.* Carotid endarterectomy can be safely performed in patients requiring coronary artery bypass grafts. *Am J Surg* 1994; **168**: 94–97.
16 Akins CW, Moncure AC, Daggett WM *et al.* Safety and efficacy of concomitant carotid and coronary artery operations. *Ann Thorac Surg* 1995; **60**: 311–318.
17 Gardner TJ, Horneffer PJ, Manolio TA *et al.* Major stroke after coronary artery bypass surgery: changing magnitude of the problem. *J Vasc Surg* 1986; **3**: 684–694.
18 Brener BJ, Brief DK, Alpert J, Goldenkranz RJ, Parsonnet V. The risk of stroke in patients with asymptomatic carotid stenosis undergoing cardiac surgery: a follow-up study. *J Vasc Surg* 1987; **5**: 269–277.
19 Mills SA. Risk factor for cerebral injury and cardiac surgery. *Ann Thorac Surg* 1995; **59**: 1296–1299.
20 Schwartz LB, Bridgman AH, Kieffer RW *et al.* Asymptomatic carotid artery stenosis and stroke in patients undergoing cardiopulmonary bypass. *J Vasc Surg* 1995; **21**: 146–153.
21 Ricotta JJ, Faggioli GL, Castilone A *et al.* Risk factors for stroke after cardiac surgery: Buffalo Cardiac-Cerebral Study Group. *J Vasc Surg* 1995; **21**: 359–364.
22 Coyle KA, Gray BC, Smith III RB *et al.* Morbidity and mortality associated with carotid endarterectomy: effect of adjunctive coronary revascularization. *Ann Vasc Surg* 1995; **9**: 21–27.
23 Lynch J, Kaplan GA, Salonen R *et al.* Socioeconomic status and carotid atherosclerosis. *Circulation* 1995; **92**: 1786–1792.

24 Rutherford RB. Cardiac risk assessment prior to carotid endarterectomy. *Semin Vasc Surg* 1995; **8**: 11–20.
25 Schepens MA, Vermeulen FE. Management of associated coronary and carotid artery disease. *Curr Op Cardiol* 1996; **11**: 525–532.
26 Banoub MC, Nugent MR. Concomitant cardiac and non-cardiac procedures. In: Estafanous FG, Barash PG, Reves JG, eds. *Cardiac anesthesia: principles and clinical practice.* Philadelphia: Lippincott Company, 1994: 663–664.
27 Lynn GM, Stefanenko K, Reed JF *et al.* Risk factors for stroke after coronary artery bypass. *J Thorac Cardiovasc Surg* 1992; **104**: 1518–1523.
28 Mickleborough LL, Walker PM, Takagi Y *et al.* Risk factors for stroke in patients undergoing coronary artery bypass grafting. *J Cardiovasc Surg* 1996; **112**: 1250–1258.
29 Safa TK, Friedman S, Mehta M *et al.* Management of coexisting coronary artery and asymptomatic carotid artery disease: report a series of patients treated with coronary bypass alone. *Eur J Vasc Endovasc Surg* 1999; **17**: 249–252.
30 D'Agostino RS, Svensson LG, Neumann DJ *et al.* Screening carotid ultrasonography and risk factors for stroke in coronary artery surgery patients. *Ann Thorac Surg* 1996; **62**: 1714–1723.
31 Libman RB, Wirkowski E, Neystat M *et al.* Stroke associated with cardiac surgery. Determinants, timing, and stroke subtypes. *Arch Neurol* 1997; **54**: 83–87.
32 Gaudino M, Glieca F, Alessandrini F *et al.* Individualized surgical strategy for the reduction of stroke risk in patients undergoing coronary artery bypass grafting. *Ann Thorac Surg* 1999; **67**: 1246–1253.
33 Goldman L, Hashimoto S, Cool F, Loscalzo A. Comparative reproducibility and validity of systems for assessing cardiovascular functional class; advantages of a new specific activity scale. *Circulation* 1981; **64**: 1227–1232.
34 Tunio AM, Hingorani A, Ascher E. The impact of an occluded internal carotid artery on the mortality and morbidity of patients undergoing coronary artery bypass grafting. *Am J Surg* 1999; **178**: 201–205.
35 Executive Committee for the Asymptomatic Carotid Atherosclerosis Study. Endarterectomy for asymptomatic carotid artery stenosis. *JAMA* 1995; **273**: 1421–1428.
36 Birdi I, Bashar Izzat M, Bryan JA, Angelini GD. Normothermic techniques during open heart operation. *Ann Thorac Surg* 1996; **61**: 1573–1580.

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